fleet of reactors is well represented by the current fleet. Our first result is that one should expect about one event per year causing damage in excess of 20 Million USD. Next, to compute expected annual losses, we must assume a finite maximum loss. If we accept that the Fukushima event represents the largest possible damage, then the mean yearly loss is approximately 1.5 Billion USD with a standard error of 8 Billion USD. This brackets the construction cost of a large nuclear plant, suggesting that about one full equivalent nuclear power plant value could be lost each year on average.

If we are less optimistic and assume that the largest possible damage is about 10 times that of the estimated damage of Fukushima, then the average yearly loss is about 5.5 Billion USD with a very large dispersion of 55 Billion USD. Concerning the probability of the most extreme accidents, we have computed the 50% probability return periods for such events.[5] Hence we estimate that there is at least a 50% probability of a Chernobyl-type event (causing about 32 Billion USD in damage costs) happening in the next 30-60 years. We further estimate that there is at least a 50% probability of a Fukushima-type event (170 Billion USD) happening in the next 65-150 years.[6] Having a standard error of about 50%, these estimates are highly uncertain, but what is certain is that they are much larger than what industry estimates would suggest.

Reducing the risks

Given the high risk level, and the insufficient effectiveness of past improvements, changes that will effectively truncate the risk of extreme events are necessary. Responses following the Fukushima event may have some impact, but this remains to be seen. Further, the implementation of passive safety systems is certainly a step in the right direction. However, given the current risk level, the importance of low-carbon energy sources, and that we are already committed to the stewardship of five decades' worth of slowly decaying nuclear waste, it is clear that a significantly increased effort is needed to improve the state of nuclear technology.[7] Further, the authors strongly suggest that the industry publish a public dataset of nuclear accidents using a variety of precise and objective scientific measures such as radiation released and property damage caused. This would enable the best possible assessment of the risk, and better informed and more confident decision-making about energy policy.

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3. Data published at: https://tasmania.ethz.ch/index.php/Nuclear_events_database.
4. Not visible here is that the rate dropped from the 1960s until Chernobyl. The high observed frequency in the 1960s and 1970s for the small number of operating reactors has little influence on the cumulative estimate.
5. The time period such that the probability of observing at least one event in excess of the given size is 0.5.
6. The range of estimates is given for parameter values ranging from moderately conservative to optimistic.
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The Paris Agreement: key points

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Amid great fanfare on 12th December 2015, delegates from 195 countries adopted the Paris Agreement on climate change.[1] Its three main aims are:

1. To keep the global temperature increase to "well below 2°C" and to "pursue efforts to limit the temperature increase to 1.5°C";
2. To increase the ability to adapt to the adverse impacts of climate change; and
3. To create the financial flows necessary to achieve (1) and (2).

The Agreement includes a number of provisions for achieving these aims, some overarching ones which are legally binding, and some more specific ones which are voluntary. Key among these provisions are:

- The aim for a "global peaking of greenhouse gas emissions as soon as possible", moving to a "balance" between emission sources and sinks "in the second half of this century";
- Voluntary target levels for national emissions (called "nationally determined contributions") – and the policies and plans to support them – that are to be reviewed and updated every five years (starting in 2018), and with each set of targets to be more stringent than the previous ones;
- National plans for adaptation to the impacts of climate change;
- Processes to support transparency in national reporting;
- A mechanism for dealing with "loss and damage" arising from climate change; and
- Legal obligations on industrialised countries to provide financial assistance to developing countries for mitigating emissions and adapting to impacts, with a voluntary collective target reaching $100 billion per year by 2020, and continuing above that level until at least 2025.

Is this enough to prevent "dangerous climate change"? Current voluntary national targets are putting us on course to about 2.7°C of warming.[2] The provisions in the Agreement have the potential to help shift the world on to a course for "well below 2°C" – but it will take considerably more effort by governments, businesses and civil society for that goal to be reached.

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